

SECTION III.—FORECASTS.

FORECASTS AND WARNINGS FOR FEBRUARY, 1916.

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There will be found in the MONTHLY WEATHER REVIEW for January, 1916, statements concerning the abnormal cold in the Northwestern States, the northern Rocky Mountain Region, and the Pacific States, and the comparatively mild weather that month in much of the country east of the Mississippi River and in the West Gulf States. In the Northwestern States the month of January was one of the coldest on record, and at a number of points minimum temperatures as low as or lower than ever before recorded occurred in that region. Moreover, the cold in that region continued during the first decade of February, but soon thereafter the prolonged cold weather in that region gave way to temperatures above the seasonal average, and such temperatures continued generally west of the Mississippi River through the remainder of the month, while east of the Mississippi River February gave temperatures that averaged below the normal. Without attempting to offer an explanation as to the ultimate cause of the unusual temperature conditions referred to in the preceding paragraph, it is of interest to note that during January the pressure averaged extraordinarily high over Alaska and the Aleutian Islands and the western Atlantic Ocean, and low over the middle latitudes of the Pacific Ocean as shown by the daily reports from Honolulu, Hawaii. It has been noted on innumerable occasions that when the barometer falls at Honolulu the pressure rises over the north Pacific Ocean and Alaska, and all pronounced cold waves of the United States are commonly associated with this "upset" pressure distribution. May it not be assumed that when there is an excess of heat within the Tropics the pressure falls, the air through a considerable distance expands and rises, and the rising air flows away horizontally to the north and south, and descends in higher latitudes and produces the abnormal pressure conditions referred to as having prevailed over Alaska and the Northwest during the whole of January and the greater part of February. It will be recalled that in MONTHLY WEATHER REVIEW Supplement No. 1 the statement was made that cold weather in the interior of the United States is associated with high barometer over Alaska and the Aleutian Islands, and that warm weather in the winter months in the Eastern and Southern States is to be expected when the barometer stands high over the western Atlantic Ocean as indicated by pressures recorded at Bermuda. The recorded temperature conditions over the United States during the month of January afford a striking confirmation of these statements. The graph, figure E.H.B. 1 (XLIV—21) illustrates the abnormalities by showing the daily departures from the normal pressure at stations in these regions during the two months in question, and Table 1 herewith gives the monthly average pressures and their departures from the normal for all Alaskan stations, Honolulu, Hawaii, and Hamilton, Bermuda.

TABLE 1.—Mean pressures for January and February, 1916, compared with the normals for those months.

Station.	January.			February.		
	Normal.	Mean, 1916.	Departure.	Normal.	Mean, 1916.	Departure.
	<i>Inches.</i>	<i>Inches.</i>	<i>Inches.</i>	<i>Inches.</i>	<i>Inches.</i>	<i>Inches.</i>
Honolulu, Hawaii.....	30.01	29.90	—0.11	30.04	29.99	—0.05
Nome, Alaska.....	29.87	30.29	+ .42	29.80	30.08	+ .28
Dutch Harbor, Alaska.....	29.63	30.16	+ .53	29.60	29.78	+ .18
Tanana, Alaska.....	29.91	30.42	+ .48	29.86	30.14	+ .28
Valdez, Alaska.....	29.73	30.19	+ .46	29.78	29.90	+ .12
Eagle, Alaska.....	30.03	30.51	+ .48	29.98	30.22	+ .24
Sitka, Alaska.....	29.73	30.05	+ .32	29.82	29.91	+ .09
Hamilton, Bermuda.....	30.13	30.34	+ .21	30.09	30.14	+ .05
Horta, Azores.....	30.14	30.26	+ .12	30.10	30.39	+ .29

The data shown in the graph and the table also confirm the statement that there is a direct relation between the observed sea-level pressures over Alaska and the Aleutian Islands and the subpermanent high-pressure area over middle latitudes of the Pacific Ocean as shown by the Honolulu pressures. It will be noted that the pressure at Honolulu was below normal continuously during January and practically all of February, while Alaskan stations report the opposite departures during nearly all of the two months. This is a similar relation to that which exists between the area of low pressure that commonly has its center near and to the west of Iceland and the subpermanent area of high pressure that normally has its center near the Azores. The influence of the general distribution of pressure over the Pacific Ocean and Alaska on determining the types of storms and the tracks followed by them while crossing the United States, and also the character of the highs and the latitudes in which they cross the United States, was referred to in MONTHLY WEATHER REVIEW Supplement No. 1. This statement was to the effect that when the pressure is low over Alaska storms of the United States move in high latitudes and along the Canadian border, but that when the pressure is high over Alaska storms usually strike the Pacific coast south of the Canadian border and follow tracks far south of what otherwise would be the case. Likewise, areas of high pressure enter the United States from Canada when the pressure is high over Alaska, but from the Pacific Ocean when the pressure is low in that region.

In February, 1916, it will be noted that areas of low pressure VI, VIII, IX, and X (Chart III) are of the Alberta type and appeared when the pressure was low over eastern Alaska, as shown by the graphs for Sitka and Eagle (Chart XLIV—21). Other storms during the month either came from the Pacific Ocean in the latitude of Washington and British Columbia or else formed in low latitudes of the United States. All moving high areas during February entered the United States from Canada or formed in the northern Rocky Mountain region, and none entered the United States from the Pacific Ocean.

When there were indications on the 12th that the prolonged period of abnormal cold in the Northwestern

States was about to terminate the following special forecast was issued for distribution to States in that region:

Pressure distribution over Alaska is such as to indicate that the prolonged period of cold weather over the Northwestern States will give way to temperatures above the seasonal average within the next two to three days and moderate temperatures thereafter during the coming week.

WARNINGS IN THE WASHINGTON DISTRICT.

On the 2d storm warnings were ordered from Delaware Breakwater to Boston, the warning reading as follows:

Hoist northeast storm warnings 2 p. m. Delaware Breakwater to Boston. Increasing northeast and east winds with rain and probably snow. Storm over South Carolina will probably move northeast and increase in intensity.

On the morning of the 3d warnings were extended northward to Eastport, Me. The storm under consideration developed on the 2d in the region of counter-flowing winds between two areas of high pressure of great magnitude that had their crests over the southern plains States and in the vicinity of Bermuda. After forming over the South Atlantic States it moved rapidly northeastward in the trough that separated the two areas of high pressure and on the morning of the 3d its center was over Cape Cod and the evening of the same day its center was over Nova Scotia. During its movement northeastward it caused gales on the Middle Atlantic and New England coasts and heavy sleet and snow on the 2d and 3d in the Atlantic States from North Carolina to Maine. On the morning of the 2d the following special forecast was issued to stations in the Middle Atlantic and New England States:

Probably heavy sleet and snow will fall during the next 24 hours in the Middle Atlantic States, southern New England, and West Virginia.

This forecast was wholly verified. At the same time cold-wave warnings were issued for the South Atlantic States, except southern Florida. By the morning of the 3d temperatures had fallen to below the freezing point as far south as north-central Florida.

The next storm of importance in the Washington district formed over the lower Lakes the night of the 6th, and the morning of the 7th, when its center was over the St. Lawrence Valley; storm warnings were ordered on the Atlantic coast from Delaware Breakwater northward to Portland, Me. During the afternoon and night of the 7th the wind blew a gale in the region where warnings were displayed, the maximum velocities reported being as follows: Delaware Breakwater, 64 miles, northwest; Sandy Hook, 56 miles, west; New York, 60 miles, west; Block Island, 60 miles, northwest; Nantucket, 40 miles, northwest; Boston, 36 miles, west; and Portland, 32 miles, west. On the morning of the same day cold-wave warnings were ordered for the Middle Atlantic States and New England, decidedly colder weather following by the morning of the 8th.

From the 8th to 12th no storm of importance prevailed east of the Mississippi River, but during the night of the 12th a disturbance moved from the Mississippi Valley, increased in intensity, and reached the Middle Atlantic States on the morning of the 13th, and, as it gave unmistakable signs of increasing in intensity, warnings of north to northwest gales were ordered at 10 a. m. for the Atlantic coast from Boston to Cape Hatteras, and later in the day storm warnings were ordered south to Jacksonville. Cold-wave warnings were issued the morning of the 13th for the Atlantic States south of Maryland and the east Gulf States. This storm moved off the coast the night

of the 13th and northerly gales prevailed as forecast. Decidedly colder weather overspread the Eastern and Southeastern States following the eastward movement of this storm and on the 15th frosts and freezing temperatures occurred as far south as central Florida.

During the night of the 17th, there was a rapid increase in intensity of a storm that was moving eastward from the region of the Great Lakes. On the morning of the 18th, the center of this storm was over Lake Huron and there were indications of a secondary disturbance over the Middle Atlantic States. This type of a cyclonic system has been found to be the precursor of a severe storm on the Atlantic coast and consequently storm warnings were ordered at 10 a. m. of the 18th for the Atlantic coast from Cape Henry, Va., to Eastport, Me., the warning conveying information to the effect that the winds would shift to northerly and westerly and reach gale force during the night of the 18th. The center of the storm passed eastward and at 8 a. m. of the 19th its center was near Eastport, Me., where the barometer read 28.98 inches, and gales were then blowing from the west and north-west on the coast north of Hatteras. The following maximum wind velocities occurred during the 24 hours ended at 8 p. m. of the 19th: Providence, R. I., 59 miles west; Nantucket, 46 miles west; Block Island, 72 miles west; New York, 64 miles northwest; Sandy Hook, 64 miles west; Delaware Breakwater, 64 miles west; Norfolk, 52 miles northwest; and Cape Hatteras, 52 miles northwest. Moreover, on the 18th cold-wave warnings were ordered for the southern portion of the region of the Great Lakes, the Ohio Valley and the Middle Atlantic and New England States. By the morning of the 19th, very much colder weather had overspread these regions.

An area of low pressure that was over the lower Mississippi Valley the 23d was central over South Carolina on the 24th and, as it was of a type that usually moves northeast and increases greatly in intensity, storm warnings were ordered at 9:30 a. m. from Cape Hatteras to Boston, and at 3 p. m. the region of display was extended northward to Eastport, Me. This storm moved northeast as forecast and the morning of the 25th its center was off the Virginia Capes, and winds of gale force were general north of Cape Hatteras. Moreover, the storm winds prevailed off the Middle Atlantic and New England coasts through the 25th, 26th, and 27th, on which days storm warnings remained displayed on some portion of the coast north of Cape Hatteras.

DISTRICT WARNINGS DURING FEBRUARY.

Chicago District.—The month was uneventful as a rule, there being at no time either any sweeping cold waves or heavy snows. The temperature averaged not far from the normal, being somewhat above in the western and below in the eastern portion of the district. The precipitation was much below the normal throughout the entire district, the lows passing with their centers well to the northward, and usually being dry. Cold-wave warnings for restricted areas were issued on two or three occasions, and these were verified almost without exception. The central office on the morning of February 12, sent a long-range forecast to this station indicating a break in low-temperature conditions in the Northwest and a week of moderate temperature. The advice, which was fully verified, was given wide distribution throughout the northwestern portions of the Chicago district. The forecaster at Chicago had previously predicted a moderation for the Northwest in his general

forecast, and during the early days of the ensuing week predicted a continuation of the mild spell for a considerable period. The long-range forecast was of great service to shippers of perishable goods, railroads, and other transportation companies, and newspapers commented on it favorably.—*H. J. Cox, Professor of Meteorology.*

Denver District.—No cold waves occurred during the month, and no warnings were issued except at the close of the month. At 8 p. m. on the 29th an anticyclonic area of moderate intensity was spreading southward over Montana and cold-wave warnings were issued for eastern Colorado. These warnings were verified by a 24-hour fall in temperature in eastern Colorado of 20° to 30°, and were followed within 36 hours by temperatures ranging from 5°F. to 10°F.—*Frederick W. Brist, Assistant Forecaster.*

New Orleans District.—Cold-wave warnings were issued on the morning of February 12 for Oklahoma and the northwestern portion of east Texas, were extended in the afternoon over the northeastern and southwestern portions of east Texas and northwestern Louisiana, and were extended at night to the Gulf coast. Subsequent conditions justified the warnings. Storm warnings were ordered for the Galveston section on the 12th and storm winds occurred during the display. No general storm occurred during the month. With the exception of the cold wave that passed over the district from the 11th to 13th moderate weather conditions prevailed during the month.—*I. M. Chne, District Forecaster.*

Portland, Oreg., District.—Owing to interruptions in the telegraph and cable services during the month, the making of forecasts was encumbered with difficulties. A sleet storm on the 2d prostrated the wires for 20 miles or more in all directions from Portland and the damage was equally as severe in the neighborhood of Seattle and Tacoma. It was a week or ten days after the storm before the telegraph and telephone companies were able to resume business on a normal basis. Besides the interruption caused by the sleet storm, reports from Alaska were missing for nearly the entire month due to cable trouble, and many reports from the stations in the Aleutian Islands were not received during the first half of the month, which was the time when they were most needed. Storm warnings were issued on the 1st, 5th, 8th, 9th, 13th, and 29th; small-craft warnings on the 7th, 13th, 17th, and 28th. Only one general storm warning was issued, the others being for small areas where the conditions were apparently threatening, and most of these threatening conditions did not develop verifying velocities. The general storm warning was issued on the evening of the 8th to coast stations, and extended the next morning to inland seaports. It was followed by maximum velocities ranging from 36 to 60 miles an hour, and was especially severe on Puget Sound. Live-stock warnings were issued on the 3d, 4th, 5th, 28th, and 29th. Live-stock warnings are a new feature, and those issued on the 3d, 4th, and 5th were to one locality upon special request and in advance of the authorization for the service. They were fully verified and favorably commented on by the recipient. Live-stock warnings were again issued on the 28th to all but four distribution centers, and on the next morning these four centers were notified of expected cold, stormy weather. This warning was fully verified and a newspaper clipping informs us that it was of "much value" to stock raisers. Warnings were issued that the hazard from avalanches would be greatly increased during the period from the 8th to 10th. This class of warnings is also a new departure, and pertained to the increase

of the hazard from avalanches. These warnings were issued on the 7th, 8th, and 9th, the first one being an advanced notice of the approach of warmer, windy weather with rain, which is the kind of weather that always causes numerous avalanches when the snow is heavy in the mountains. The subsequent avalanche warnings were for the purpose of calling attention to the fact that the danger period had not yet passed. These warnings were fully justified, judging from newspaper items which contained many notices of slides and avalanches during the period covered by them.—*E. A. Beals, District Forecaster.*

San Francisco District.—There were no storms of a dangerous character nor were there any damaging frosts.—*G. H. Willson, District Forecaster.*

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RELATION BETWEEN RAINFALL AND SYNOPTIC WINDS.

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[Argentine Meteorological Office, Buenos Ayres. MS. recorded Feb. 24, 1916.]

Rainfall is one of the most important elements, yet it occurs in such irregular, spotted areas as to defy even the most skilled forecaster. For example, on the weather map for May 22, 1913, shown in the accompanying figure figure H. H. C. 1 (XLIV-22), there is an area of rain in the Lake Region and New England, another in the lower Mississippi Valley, and a third on the Pacific coast.

In seeking more definitely the conditions which attend rain, it is well to consider its physical causes. Rain is caused by the chilling of moist air below the point of saturation, so that a part of the moisture falls out. Experience indicates that the most potent if not the only cause of this cooling is the expansion of ascending air as it comes under diminished pressure aloft. The ascent of the air may be induced by: (1) Topography, as for example where air is forced over mountain ranges; (2) heating at the ground, which determines the formation of local ascending currents resulting in cumulus clouds and local showers; (3) converging or opposing winds determined by horizontal differences of temperature and pressure.

The first of these is a climatic factor which a forecaster needs to keep in mind, and the second is the cause of occasional showers, specially in summer, but experience shows that the third is the main cause of our ordinary rainstorms.

When winds are diverging a descent of air is indicated and consequently fair weather, because descending winds are dry. On the contrary, when winds are converging ascending air is indicated and consequently expansion and cooling, resulting in clouds and rain.

The factors determining the intensity of the rainfall are, (1) the angle of convergence, (2) the speed of the wind, (3) the moisture content of the air, and (4) the topography. Coefficients would need to be determined for all these in a proper formula.

The wind is usually indicated on the weather maps to eight points of the compass, and this permits a scale of four steps both for diverging and converging winds, thus (1) ↑ ↗, (2) ↑ →, (3) ↑ ↘, (4) ↑ ↓, for diverging, and a similar scale for converging winds. If on the weather map the diverging winds are marked with red and the converging winds with blue in accordance with the above scale, it becomes apparent that the red marks are located, as a rule, in regions of fair weather and the blue marks in